Counting: an imprecise reference standard for respiratory rate measurement

Mark Ansermino J[1], Amy Sarah Ginsburg[2], Dustin Dunsmuir[1], Walter Karlen[3], Heng Gan[4], Catherine Muthoni Njeru[4], and Guy Dumont[1]

[1]The University of British Columbia
[2]University of Washington
[3]Universitat Ulm
[4]BC Children's Hospital

September 12, 2022

Abstract

In response to: Spurr R, Ng E, Onchiri FM, Rapha B, Nakatumba-Nabende J, Rosenfeld M, Najjingo I, Stout J, Nantanda R, Ellington LE. Performance and usability of a new mobile application for measuring respiratory rate in young children with acute lower respiratory infections. Pediatr Pulmonol. 2022 Aug 22. doi: 10.1002/ppul.26125.

To the Editor,

In response to: Spurr R, Ng E, Onchiri FM, Rapha B, Nakatumba-Nabende J, Rosenfeld M, Najjingo I, Stout J, Nantanda R, Ellington LE. Performance and usability of a new mobile application for measuring respiratory rate in young children with acute lower respiratory infections. Pediatr Pulmonol. 2022 Aug 22. doi: 10.1002/ppul.26125.

Counting: an imprecise reference standard for respiratory rate measurement

We applaud the authors for critically considering and quantifying attributes that impact the measured performance characteristics of the respiratory rate (RR) measurement applications (apps) they evaluated.[1] It was not surprising that most of the variability was attributable to patient RR variability and observer variability, and that given the accuracy of timing a tap on a smart phone screen is likely to be within a few milliseconds,[2] the measurement apps themselves contributed minimally (0.6%) to overall variability. However, a potential limitation in the comparisons made in this study and also in some of our previous studies may be due to the variability in the reference standard. While counting breaths to measure RR has been practiced by clinicians for decades, this historical reference standard is problematic. The issue with counting breaths to determine RR is that the true underlying physiological RR is typically rounded down by the observer to the nearest breath. As RR is usually distributed close to a mean of 20 breaths per minute in children, this rounding alone can result in an average error of 5%. With an average RR of 55 breaths per minute among the children in this study, this average error would be even higher due to the difficulty of an observer counting at this rate. To account for within-patient RR variability when evaluating the performance of electronic RR apps, we suggest the inter-breath interval be measured and summarized as the interval over more than one breath.

When using manual breath counts as the reference standard in their study, Spurr et al. observed the correlation and proportion classified as fast breathing with the ALRITE app to be higher in comparison to the RRate app (Spearman's coefficient 0.83 vs 0.62). This is not unexpected as the same rounding down was performed in the ALRITE app as with the visual counting reference standard. In contrast, rather than counting specific breaths, the RRate app is designed to measure a precise inter-breath interval and to calculate a RR that represents the median value of the measured breath intervals.[3] Thus, this value is likely to be different from a count over one specific time interval. When measuring RR, if the intent is to measure the underlying physiology that is triggering each breath, measuring a breath interval is likely to be more precise than counting breaths.[4]Given that the RRate app's average number of taps to measure RR in the study was 6, at a median RR of 55, the RRate measured the RR in 6.5 seconds, and would not be equivalent to a RR measured over 30 or 60 seconds, especially in infants in whom RR variability is much higher at faster RRs.[5] To facilitate a more accurate comparison of the two RR apps and a more precise estimate of the repeatability of breath count observations, the authors could consider measuring the breath intervals by identifying a specific video frame in the video recordings used in the study for each breath. The RR could then be calculated using the average time interval between these breaths. This could also be used to evaluate the precision of breath counting. In summary, we support the authors in quantifying attributes that impact the measured performance characteristics of RR measurement apps and in promoting the simplicity and precision of touching the screen of a phone to time breathing.

Correction: The RRate app has not been commercialized and the algorithms are not proprietary and have been made free to everyone, including the source code.

(https://github.com/part-cw/LNhealth).

References

1. Spurr R, Ng E, Onchiri FM, et al. Performance and usability of a new mobile application for measuring respiratory rate in young children with acute lower respiratory infections. *Pediatr Pulmonol* 2022.

2. Ambritta NP, Damini, Bhandwalder HP. A Survey on Real-Time Application Latency Based on Android OS. *IEEE Xplore: 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA)* 2019: 1-4.

3. Gan H, Karlen W, Dunsmuir D, et al. The Performance of a Mobile Phone Respiratory Rate Counter Compared to the WHO ARI Timer. *J Healthc Eng* 2015; **6** (4): 691-703.

4. Coleman J, Ginsburg AS, Macharia WM, et al. Assessment of neonatal respiratory rate variability. *J Clin Monit Comput* 2022.

5. Njeru CM, Ansermino JM, Macharia WM, Dunsmuir DT. Variability of respiratory rate measurements in neonates- every minute counts.*BMC Pediatr* 2022; **22** (1): 16.

J Mark Ansermino, MBBCh, The University of British Columbia, Room V364, British Columbia Children's Hospital Research Institute, ; anserminos@yahoo.ca

Amy Sarah Ginsburg, MD, MPH, Clinical Trials Center, University of Washington, Seattle, Washington, United States; messageforamy@gmail.com

Dustin Dunsmuir, MSc, The University of British Columbia, Room V353, British Columbia Children's Hospital Research Institute, ; DDunsmuir@cw.bc.ca

Walter Karlen, PhD,, ; walter.karlen@

Heng Gan, MBBCh, Department of Anesthesia, British Columbia Children's Hospital, Vancouver BC V6H 3V4, Canada; Heng.Gan@cw.bc.ca

Guy Dumont, PhD, The University of British Columbia, Rm V348, British Columbia Children's Hospital Research Institute, 950 West 28th Ave., Vancouver, BC, Canada; guyd@ece.ubc.ca

The authors have no competing interests to declare.